416-96 (R.) British Dec. 1971

1257041 COMPLETE SPECIFICATION

3 SHEETS This drawing is a reproduction of the Original on a reduced scale

Sheet 2

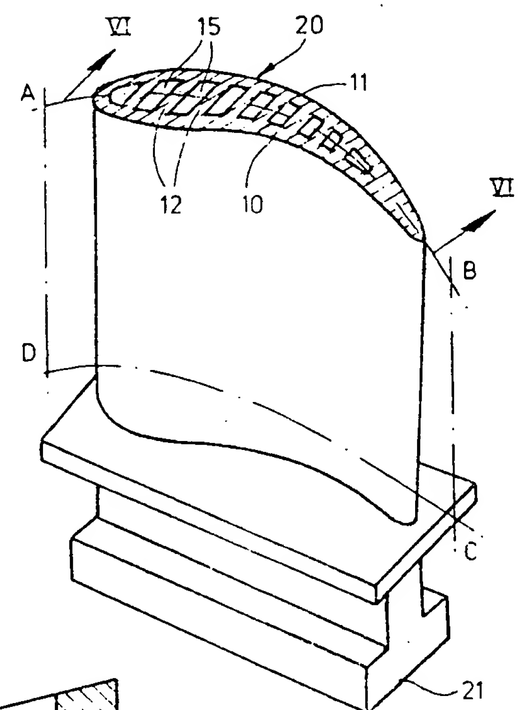

FIG. 5

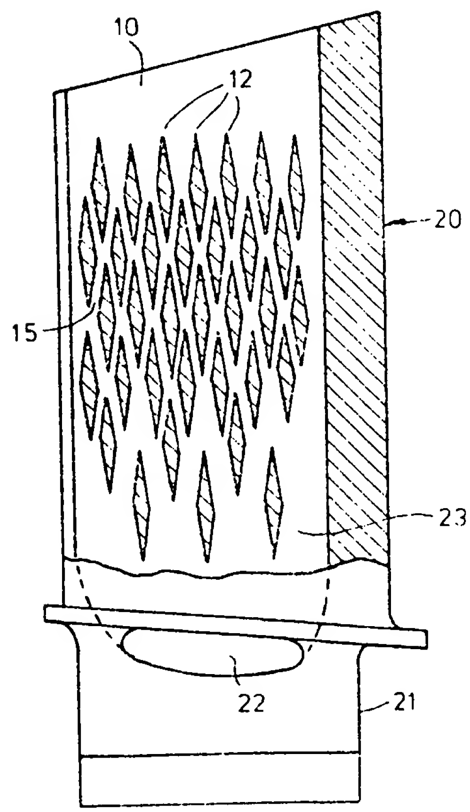

FIG. 6

92
97

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Sheet 1

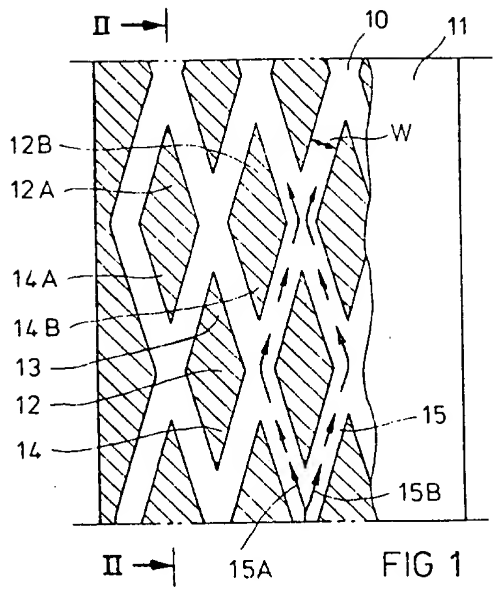

FIG 1

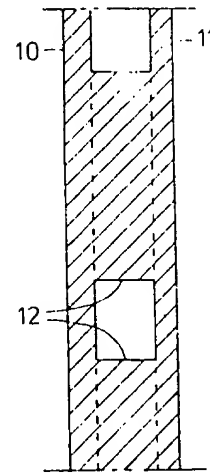

FIG 2

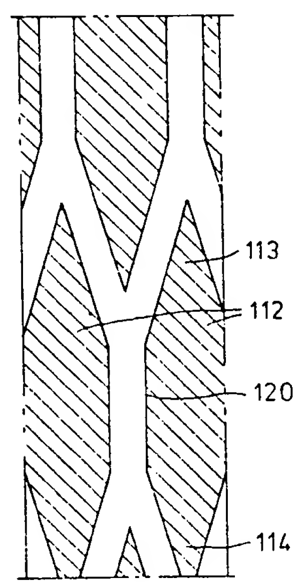

FIG 3

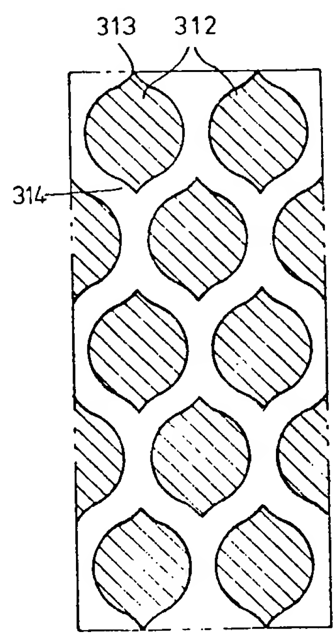

FIG 4

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Sheet 3

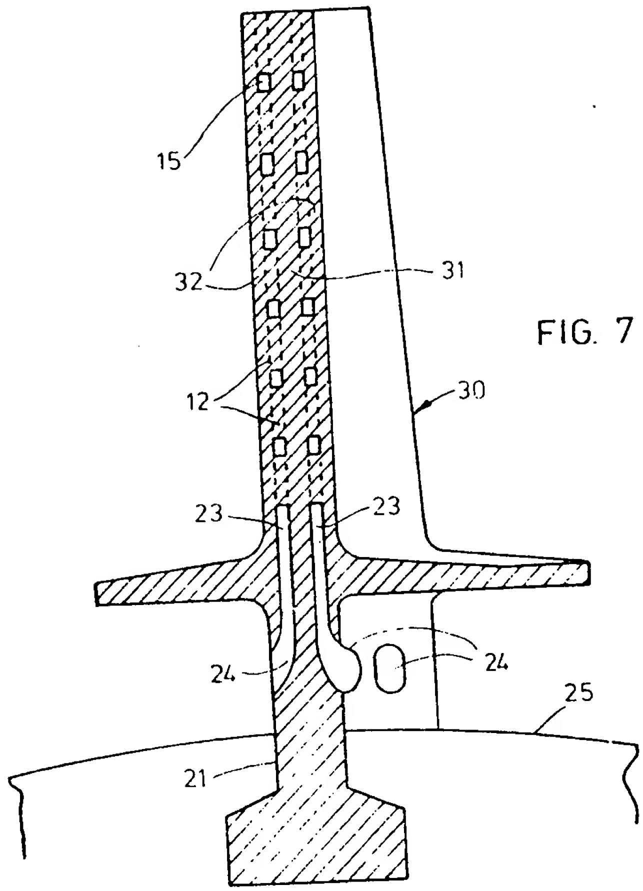

FIG. 7

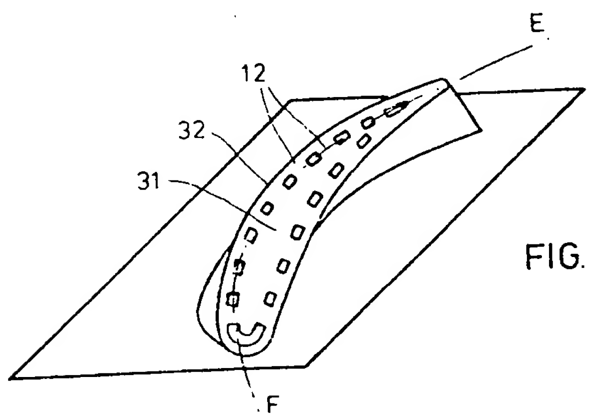

FIG. 8

7 971 7

PATENT SPECIFICATION

(11) 1 257 041

DRAWINGS ATTACHED

1 257 041

(21) Application No. 14662/68 (22) Filed 27 March 1968

(23) Complete Specification filed 23 June 1969

(45) Complete Specification published 15 Dec. 1971

(51) International Classification F 28 f 13/02 F 01 d 5/18

(2) Index at acceptance

F4S 4E
F1T 2F2B

(72) Inventor ALAN MOORE

(54) HEAT EXCHANGER

(71) We, ROLLS-ROYCE LIMITED, a British Company of Moor Lane, Derby, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to heat exchangers.

According to this invention a heat exchanger comprises two opposite walls connected by islands having tapered end portions and being arranged to be so interdigitated that the tapered end portions of any one island extends between the tapered end portions of adjacent islands to define between the islands sequentially converging and diverging flow passages of substantially uniform cross-sectional area.

The sequential coverging and diverging of the flow passages brings about discontinuities of boundary layer desirable for good heat transfer. In the past discontinuity of boundary layer was associated with disuniformity of flow area. The present invention makes it possible to combine discontinuity of boundary layer with uniformity of flow area thereby avoiding the pressure losses associated with disuniformity of flow area.

Examples of heat exchangers according to this invention will now be described with reference to the accompanying drawings wherein:—

Fig. 1 is a sectional elevation of a first example of a heat exchanger according to this invention.

Fig. 2 is a section on the line II—II in Fig. 1.

Fig. 3 and 4 are sectional elevations of a second and a third example, respectively, of heat exchangers according to this invention.

Fig. 5 is a perspective view of a turbine blade embodying a heat exchanger according to this invention.

Fig. 6 is a section on the line VI—VI in Fig. 5.

Fig. 7 is a sectional elevation of a blade similar to that shown in Fig. 5 but embodying a modification.

Fig. 8 is a plan view of Fig. 7.

Referring to Fig. 1, the last heat exchanger comprises two opposite walls 10, 11 connected by islands 12. The shape of the islands is such that, as seen in a plane nominally parallel to the walls, the islands manifest tapered end portions 13, 14 and are so arranged or interdigitated that the tapered end portions of any one of the islands lies between the corresponding end portions of two other islands. Thus the end portion 13 lies between end portions 14A, 14B of two islands 12A, 12B. By this arrangement the islands form therebetween fluid flow passages 15 so related that any two adjacent such passages alternately converge and diverge as indicated by flow lines 15A, 15B. Further the islands are arranged for the width W of each passage to be substantially uniform so that (assuming substantially uniform spacing in the flow direction between the walls 10, 11) the cross-sectional area of the passages 15 is substantially uniform.

It will be seen that the boundary layers between the flow and the islands is discontinuous, i.e. is interrupted and reformed as the flow passes from one island to the next, and this provides a higher coefficient of heat transfer than is the case where the flow passages do not divide and converge, e.g. are parallel. At the same time, the uniformity of flow area made possible by interdigitation of the tapered end portions of the islands avoids or diminishes the pressure losses associated with local disuniformities of flow area. In consequence the mass flow throughput and thus the heat transfer rates and the thermal capacity of the heat exchanger are better than in heat exchangers which do not have the island configuration described.

In Fig. 1 the islands are of diamond cross-section. Other cross-sections are possible as shown in Figs. 3 and 4.

In Fig. 3 islands 112 are similar to those shown in Fig. 1 except that they are elongated to have parallel portions 120 between tapered end portions 113, 114.

In Fig. 4 islands 312 are basically of circular shape and each have tapered extensions 313, 314 to ensure substantial uniformity of flow area.

In Figs. 5 and 6, the heat exchanger shown in Figs. 1, 2 is applied to a turbine blade 20 for a gas turbine engine and reference numerals applied in Fig. 1 are applied to corresponding features in Figs. 5 and 6. The blade has a root portion 21 including an opening 22 for the reception of cooling air and a passage 23 generally defining the hollow interior of the blade. The islands 12 are arranged between the walls 10, 11 which in this case define the sides of the aerofoil section of the blade. As shown, the density of the islands is greater at part of the blade where the greatest cooling effect is required, i.e. the part medially between the radial ends of the blades.

The blade is made of metal by a casting process including the insertion of a mould of a core defining the passages 23, 15. The core is made of material, e.g. silica, capable of being removed after casting by chemical means in a manner known per se. The core itself can readily be made in a two-part mould divided on the plane A, B, C, D in Fig. 6.

In Figs. 7, 8 there is shown a blade similar to the blade 20 but wherein there are two passages 23 each arranged in a layer near and parallel to the exterior surface of the blade so that the blade may be said to comprise a spine 31 and an outer sheath 32 of substantially uniform thickness, the islands 12 connecting the spine 31 and the sheath. In this way the cooling effect is brought close to the surface of the blade. The spine 31 may itself be hollow. To provide access for cooling air from the root portion 21 of the blade to the passages 23 openings 24 at the respective sides of the root portion are connected to the respective passages 23. A disc on which the blade is mounted in a manner known per se is denoted 25.

WHAT WE CLAIM IS:—

1. A heat exchanger comprising two opposite walls connected by islands having tapered end portions and being arranged to be so interdigitated that the tapered end portions of any one island extends relative to the tapered end portions of adjacent islands to define between the islands sequentially converging and diverging flow passages of substantially uniform cross-sectional area.

2. A heat exchanger according to claim 1 wherein the islands are of diamond or similar lozenge cross-section.

3. A heat exchanger according to claim 1 wherein the islands are shaped to have convex sides at the central or body part thereof and wherein the tapered end portions of the islands have concave sides which are parallel to the confronting convex parts of any adjacent island.

4. A heat exchanger according to any one of the preceding claims being in the form of a turbine blade including said flow passages adjacent the aerofoil surfaces thereof, and the flow passages being connected to cooling air inlets in the root portion of the blades.

5. A heat exchanger substantially as described herein with reference to Figs. 1 and 2, or any one of Figs. 3 or 4 of the accompanying drawings.

6. A heat exchanger in the form of a turbine blade substantially as described herin with reference to Figs. 5 and 6 or Figs. 7 and 8 of the accompanying drawings.

For the Applicant:
G. S. COURTNEY,
Chartered Patent Agent.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1971.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.